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ABSTRACT

The development of a faculty information system at Carnegie Mellon University is traced using a case study approach. Attention is focused on the process of system design by committee, the resulting relational database, and its impact on institutional research and university reporting. Technical implementation and details of the system design are covered. Goals for the system were to provide: access to both current and historical information; and an integrated database of faculty information from which queries, reports, and analyses could be easily generated. The ultimate goal was to provide information to support faculty-related decision-making processes, both centrally and in colleges and departments. The relational database management system, INGRES, was chosen for development of the information system. Included in the system were biographical, salary, teaching, and research data. Future directions in the ongoing project include the development of a university information system that will integrate faculty, student and space data, and the transfer of data from this system through the campus-wide network of personal computers. (SW)

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DEVELOPING A FACULTY INFORMATION SYSTEM AT CARNEGIE MELLON UNIVERSITY

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Ann K. Dickey, Chair
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ABSTRACT

The success of institutional research efforts depends upon easy and often immediate access to complete and accurate data. This paper uses a case study approach to trace the development of a faculty information system at Carnegie Mellon University. The discussion focuses on the process of system design by committee, the resulting relational database, and its impact on Institutional Research and university reporting. The process and the resulting system are then evaluated. Future directions in this on-going project include the development of a university information system which will integrate faculty, student and space data, and the transfer of data from this system through the campus-wide network of personal computers.

INTRODUCTION

Carnegie Mellon University is known for its efforts in the area of academic computing. The development of a faculty information system to serve the campus community was the first step in a series of projects which will upgrade administrative computing. Valuable lessons were learned from this development effort, which laid the groundwork for future cooperation between college and administrative units in the realization of common goals. The Institutional Research division, in collaboration with CMU's Administrative Systems (AS) department, was instrumental in the design and development of this system and was a major beneficiary of the resulting improved access to integrated information.

HISTORICAL PERSPECTIVE

Investigation into the possibility of developing a system which would contain information about faculty began in early 1983. Discussions among personnel in several central administrative offices highlighted the need for a more flexible means of obtaining information about faculty for purposes of individual review and summary data analysis. In the same time period, one college was actively pursuing the development of a database containing information on its own faculty to meet the same kinds of needs. These projects coalesced in late 1983, with the initiation of the Faculty Information System (FIS) Project, under the auspices of the Director of University Planning. This system would be designed by a committee of university representatives to meet the common and specialized needs of central administrative, college and department users.

The need for accessible, comprehensive information about faculty from a single source was well documented. Diverse offices on campus were individually compiling information about faculty using paper files, standard reports or locally developed databases. This information was needed for a variety of similar projects, from individual salary review to tenure, flow and workload analyses and survey responses. Coming from a variety of sources, information used within the university, and reported to external agencies, was often inconsistent.

Most of this information about faculty was gathered and stored centrally, in the Payroll/Personnel and Student Records systems on one of the university's mainframe computers. These systems were designed for use by the respective administrative offices to accomplish their specific functions. Constraints imposed by hardware, software and data communications prohibited easy access to these systems by all campus community members who needed to make use of the data.

GOALS

The purpose of the Faculty Information System Project was to provide authorized members of the campus community with flexible, easy access to centrally stored information about faculty. The specific goals, outlined at the initiation of the project were:

- To provide an integrated database of faculty information from which queries, reports and analyses could be easily generated; and
- To provide access to both current and historical information.

The ultimate goal was to provide information which would support faculty-related decision-making processes, both centrally and in the colleges and departments. This system was not, however, designed as a true Decision Support System. It lacks a modeling component or specific tools which would directly assist a decision-maker in planning and problem-solving (Moore and Greenwood, 1984, Sheehan, 1982, Karon, 1986). Consistent with CMU strategy for computer use, the objective was to provide information and to encourage users to download this information into modeling software housed in a personal computer or on the local area network. This de-emphasizes the time-sharing mode of operation necessary for storage of such large sets of data.

SYSTEM DESIGN BY COMMITTEE

The FIS was designed by a committee comprised of members from the Planning Office, in a coordinative role, members of Administrative Systems, who were to undertake the actual development, and representatives from each of the administrative and college offices who would develop specifications for the system. The committee of approximately 18 members had the responsibility for defining the content of the system and for designing the appearance of the

on-line screens. The latter was the task to which the most time was devoted. This "design-by-committee" or user-controlled design approach is part of an overall philosophy of systems design that hinges on user participation. The practice of including the users in the design process allows them to set system criteria and have control over the design of the interface between themselves and the system (Lucas, 1982). The FIS project was the first large-scale administrative project at CMU to use this approach.

The central role of the Institutional Research division in the development of this system flows naturally from Institutional Research expertise in gathering, interpreting and analyzing university data (Saupe, 1981). This is not a new role but rather one which has evolved with the increasing reliance on computerized information systems. Institutional Research professionals directed committee meetings and discussions, investigated data needs and problems and worked to build a consensus where the perspectives and needs of users varied. The original design process lasted for two years, but the committee continues to meet occasionally to discuss on-going issues and to plan future developments.

GENERAL SYSTEM DESIGN

Certain features of the general system design were established at the beginning of the project. The committee determined that the ideal system would include biographical, salary, teaching, research and publications data, and would eventually provide an on-line vita for all faculty members. Projects were to be tackled one at a time, beginning with a biographical screen. The following operating assumptions were defined at the outset of the project and the expectations of the system were set.

- First, the Faculty Information system would be developed in a relational database management system (DBMS), chosen to provide easy access to information about individuals through on-line screens and to summary data by means of a flexible retrieval capability.

- This would be a "retrieval" system, fed with information from the current Payroll/Personnel and Student Records systems. Central processing of Payroll/Personnel and Student Records data would continue in the originating systems. Any changes needed in FIS data would be made through these originating systems, following established procedures, and be passed back to the FIS.

- The system would be used to accumulate historical information previously stored only on paper records or on computer tapes.

- Data entry would be kept to a minimum, but would be available for a few data items not currently stored on the central production systems. This information would be entered by users at the department level.

- The system would eventually become an employee information system, storing data about all university employees.

TECHNICAL IMPLEMENTATION

The technical implementation was the responsibility of the Administrative Systems Department. One full-time programmer/analyst was assigned to the project and worked closely with the Planning Office and the FIS committee in designing the database, transferring the data and developing the user interfaces.

The decision regarding the hardware and software to be used in building the system was based upon available database technology and available CMU resources. In an effort to keep abreast of new developments and products in the database field, a state-of-the-art relational database management system, INGRES, was chosen as the vehicle for development of the FIS. INGRES is a product of Relational Technology, Inc., Alameda, CA.

A "relational" system is designed to follow the set of principles that form the "relational model" (Codd, 1982). This model provides a way of looking at and manipulating data that offers users great ease of use and powerful data retrieval capabilities. The relational model's way of representing data as grouped in sets or tables (often called "relations") is easy for users and database programmers alike to understand. Data items and the relationships between these items are presented to the user in logical tabular form. "Views", or logical representations, of the same data can be created for users who need regular access to different combinations of data elements.

Although relational and relational-like DBMS products were available for micro-computers, a mainframe DBMS was chosen for the FIS. Since the data would be shared by many users across campus and since some of the data are highly confidential in nature, central control of the data was necessary. Further, the large quantity of data required a machine with sufficient

storage capacity. The INGRES software runs on one of CMU's VAX 11/780 mini-computers configured with 16 megabytes of memory and running the VMS operating system. This particular DBMS was already being used, with success, as the database management tool for other administrative applications. Investigations into the capabilities of the product suggested that it would offer a good development environment for the system. The user interfaces, such as the forms system and report writing capabilities and the programmer tools of INGRES offered the flexibility and ease of use important in a DBMS.

An additional advantage of INGRES, which was also very important to the FIS project, is its ability to carefully control access to the data. An elaborate system of "permissions" exist in the FIS, granting users access to specified information (e.g., biographical only, biographical and salary) about faculty in their department or college. The VAX VMS operating systems provides an additional overall level of security, offering protection schemes at the user account, directory and file levels.

Procedures were established to move data from the Payroll/Personnel system to the FIS on a regular basis. Data files are shipped once a week from the originating systems across a network to the VAX, where they are loaded into the database. The FIS is comprised of a series of screens which users access through a main menu. Information is displayed based upon values entered into any field on the screen. Users may also retrieve selected data elements by writing their own ad hoc queries. The FIS is supported by Administrative Systems in technical, user training and ongoing user-assistance capacities.

DETAIL SYSTEM DESIGN

The design process was accomplished through a series of monthly meetings, during which time committee members determined what categories of individuals would be included in the Faculty Information System and designed screens to meet user needs for information on individual faculty members. The starting point for these discussions was a series of screen mock-ups submitted by an AS programmer/analyst. The committee reaction to these mock-ups was immediate and strong; the designs did not portray information in a format which would

meet their needs. This was a lesson to all participants, i.e., knowledge of the data itself does not translate into knowledge of useful methods of organization. As a result, the committee spent considerable time discussing, in elaborate detail, the format and content of each screen. The goal was to ensure that the information would be useful to the campus community.

Five screens were designed over the two year period, during which time the INGRES database was also designed and put into operation. The first screen, a Faculty Biographical Screen, was designed to display basic biographical and appointment information on individual faculty members. The second, showing salary payments to faculty members, evolved into a series of three linked screens. These screens list salary data in three levels of detail: five years of payments by year and time period (academic and summer payments); one year's payments by category (E&GO, Research and Other); and one year's payments by center and account number within the above categories. The third effort was the design of a Faculty Teaching and Evaluation Screen, in which a record of courses taught and their teaching evaluation scores was to accumulate for five years. The purpose of the salary and teaching screens was to aid in the process of salary and tenure review.

During the design process the committee faced two significant challenges. The first was to coordinate college and administrative user perspectives on the data so that the final system would be equally valuable to all. This required that committee members develop a common set of useful data definitions and agree upon who would have access to what information, as well as agree upon the format in which to display the data. This process resulted in improved communication between college and administrative offices, but it also required some minor university policy changes and a few alterations in the Payroll/Personnel and Student Records systems. The cooperation and support of those responsible for the originating systems was critical to the success of this project. The second, more technical challenge was to accurately link together data items from several production systems. This latter task was significantly more difficult.

The first task of the committee was to reach an agreement on which categories of

individuals should be included in the system. After several committee meetings and considerable investigation by members of the Planning Office, a broad group of job class codes was chosen to define the composition of the original Faculty Information System. These included full-time tenure-stream positions, full- and part-time non-tenure stream teaching positions, and faculty-equivalent research/scientist positions. While all committee members agreed at the outset on the inclusion of tenured and tenure stream faculty, this decision represented a new agreement on the definition of the ambiguous category of "Special Faculty". In the past, administration and college offices had used different definitions of special faculty. Traditionally, the administration relied on government EEO codes, which encompassed only teaching positions, when counting special faculty. The colleges evaluated other factors, such as salary, benefits and job status, which resulted in the inclusion of the top layer of research positions. Consistent with college practices, the Planning Office has now adopted this definition, and, due to the availability of information about these individuals on-line, now annually monitors changes.

Committee discussions about the data for the screens, and the format in which to present these data, led to requests for changes in the originating systems. On-going dissatisfactions with the production systems were raised and had to be addressed. For example, discussions of job categories for inclusion in the system raised problems with available classifications and led to the addition of several new university job class codes to the Payroll/Personnel System. In some cases committee specifications for data presentation could not be accommodated without alterations in Personnel policies and changes in the originating system. One major issue concerned how information about faculty joint appointments should be captured and displayed. In CMU's decentralized environment, each college defines what constitutes a joint appointment for its faculty. A standardized means for colleges to transmit this information to the central administration did not exist. As a result of committee discussions, changes were made to the Payroll/Personnel System to allow colleges and departments to indicate a faculty joint appointment and the percent of that appointment to be counted in a department. Additional changes made it possible to include and count special appointments, such as courtesy

appointments, that have no associated salary payment. For the first time the Planning Office was able to count faculty in their joint appointments in a manner which was consistent with counts produced by the colleges and departments.

The joint appointment issues were also significant in the process of granting users access to salary screens and data. CMU is a private university and salary information is strictly confidential. Only summary data, such as that reported to HEGIS, is made public. Departments with joint faculty members had varying arrangements for sharing access to salary information; most important was the fact that not all had equal access to the total salary picture. Therefore, a structure of FIS permissions was designed in which the individual's home department had access to all salary data while other departments had access only to data related to payments they made. This was the standard for the first year and a half of system operation, during which time users discovered that they could not accomplish certain tasks, such as calculating an average salary by department, because of the distortions induced by the partial salary views. The committee then reevaluated the structure of the permissions and the practices of their departments. After much discussion, it was decided that all departments in which an individual had a specified joint appointment would have access to all salary information; other departments providing payments to an individual would see only their payments, as before. This new structure is currently being implemented, reflecting a new level of cooperation between colleges and departments.

Combining data from different production systems into a centralized inquiry system was the most complicated task mandated by the committee. Data for the Biographical and Salary screens, the first two completed, were drawn entirely from the Payroll/Personnel system. While it was difficult to reconfigure data from this system to meet user needs, it was a manageable operation. The Faculty Teaching and Evaluation Screen required data from three systems: Student Records, Payroll/Personnel and Faculty Course Evaluation (FCE). Significant problems were encountered in the attempt to accurately match data items for each faculty member from the different systems. In some cases, data were incomplete (e.g., names of instructors teaching courses in the Student Records system were missing), in others, they were

inconsistent between systems. These problems prompted an in-depth investigation by Institutional Research professionals into the operational data flow into the Student Records System. It was discovered that the problems had two primary sources. First, departments did not always supply fully accurate data to the Registrar's office after the semester had begun. Members of the FIS committee were instrumental in emphasizing the importance of this task and encouraging improved departmental compliance. Other data problems lay within the structure of the Student Records and FCE systems. Finding solutions to these problems was beyond the scope of the FIS project, but effort continues to be directed toward their resolution. These difficulties derive from the attempt to use data from inflexible systems which were designed for other purposes. They also highlight problems inherent in trying to combine data from different systems.

Finally, with committee approval, the FIS was transformed into an Employee Information System by the inclusion of information about all non-student employees in the university. This was one of the original long-term goals of the FIS. Its implementation was prompted by changes in Personnel Office procedures, which required an On-Line Personnel Action Notice (PAN) screen. This screen provided users with an on-line duplication of the paper form used to process employee information. The information now stored in the database offers users the ability to easily obtain employee data, in the same way they can get faculty data, without relying on the originating Payroll/Personnel system.

SYSTEM USE BY INSTITUTIONAL RESEARCH

While the committee effort was directed toward the development of the screens, and the internal structure of the system was largely designed to facilitate the screen design, one of the most useful aspects of this system is the capability for users to retrieve data in an ad hoc fashion. Using the INGRES query language called QUEL, users can quickly retrieve any combination of data elements, perform counts, sums, averages or other simple arithmetic operations, and/or store lists of individuals and attributes in a file for further analysis. Using another software package (Workload by Management Science Associates), it is easy to reformat

data retrieved from the database and load it into Lotus 1-2-3 (Lotus Development Corporation). The extraction of data files in specified formats for use with statistical packages such as SPSS (Information Analysis Systems) is also a straightforward operation.

The capability to perform ad hoc queries has had a major impact on the ability of Institutional Research professionals to satisfy on-going needs and to answer new questions relating to university employees without programming support. The database was immediately employed for the annual official tenure and tenure-stream faculty count. Easy access to data on-line and changes in a few of the data elements mentioned earlier combined to greatly improve both the timeliness and the accuracy of this count. Counts of special faculty, a category redefined during the development effort, were also instituted. In the second year of operation, standard reports were written to further automate this annual process. Other traditional institutional research projects, such as tracking tenured faculty, including average ages and time in tenure by college/department, were greatly simplified; new projects, such as the annual production of a faculty profile, were implemented; and many smaller questions about faculty and staff were easily and quickly answered. The most recent analysis, part of the university preparation for potential budget cuts due to the Gramm-Rudman bill, involved the calculation of the percent of salary dollars charged to Federal research, by category of employee (Faculty, Research and Other), tenure status and college. This analysis could not have been accomplished prior to the development of the FIS without considerable programming effort. Further, the fact that an analysis of this kind was never anticipated in the design of the system illustrates the flexibility of the relational database as a tool for analysis. Additional projects, such as University-wide teaching load analyses and analyses of Faculty Course Evaluation results will be undertaken when data problems are resolved.

The roles and activities of professionals in the Institutional Research division have also been affected by the implementation of this system. A primary function of institutional research is that of transforming data into information (Saupe, 1981). Since the FIS is not a true Decision Support System, the data require manipulation before they are useful as information. Institutional Research professionals have become "expert users" of the database,

understanding its contents and continually learning more about its capabilities to meet increasingly complex requests for information. Dependence on administrative programmers has greatly decreased, while the accuracy of the data distributed from the Planning Office has improved. This is a result of improved access, of the ability to actively monitor the data and of the new consensus regarding data definitions. The pioneering role played by the Planning Office in using the FIS served to demonstrate its potential and encourage use among the campus community. Finally, due to the Institutional Research role in developing and using the system as well as staff shortages, an Institutional Research professional was actively involved in all aspects of user training: assisting in training classes, visiting user offices for personalized instruction and assistance, and answering questions when users encountered difficulties using the system. Whether this level of involvement will continue in the future is questionable, but it was undoubtably useful, both in terms of providing support and encouragement to new users, and in the continuing investigation of user needs and requirements.

EVALUATION OF SYSTEM AND DESIGN EFFORT

An evaluation of the work done to date on the Faculty Information System must address two questions. First, has the system met the explicit goals established at the outset of the project? These were to provide an integrated database of faculty information from which information could be easily obtained and which would include both current and historical data. Second, is the system being used by the campus community? Finally, an evaluation of the design-by-committee approach used in this project is important for future design efforts.

The system has met the established goals and objectives in some areas, but has fallen short in others. Two primary requirements of the system, faculty biographical and salary data and screens, are fully functional, up-dated smoothly and regularly, and easily accessible. The third area addressed by the design effort, faculty teaching and evaluation history data and screen, is still incomplete and requires further attention. Additional information requirements outlined in the initial discussions, such as faculty publications history, are yet to be addressed.

The issue of user acceptance is multi-dimensional. The user community is comprised of 69

users, in positions ranging from secretarial to the president of the university. A survey conducted in April of 1985 indicated that the majority are not making use of the system. Only 15 users completed the survey; of these, 10 had used the screens and 6 used the query capabilities. Only a few of those who responded used the system either regularly or intensively during certain periods. An analysis of computer charges to the database account over the two year period shows slight but regular increases in usage by college users, and large increases by administrative users, primarily the Planning Office.

These results raise the question of whether the system met the implicit goals of the committee. That is, is the FIS a useful tool for the projects for which it was intended? The committee effort was dedicated to the design of on-line screens which were to facilitate decision-making about individual faculty members, both centrally and locally. The design and operation of the functional screens should have been successful in fulfilling this goal. The lack of use may have several possible explanations, depending on the aspect of the system being addressed. Biographical screen information, while an essential part of the system, is not needed on regular basis and is available elsewhere on paper copy. Salary data were difficult to accurately reconfigure and the resulting delays tempered initial enthusiasm. Further, salary information about some faculty members was not as useful as originally anticipated until the recent changes in access permissions were implemented. The teaching screen, which for many would eliminate significant amounts of paperwork, is still incomplete. As problems with the latter are resolved, as users see the advantages of the new salary permissions, and as a longer historical record of salary data is accumulated (only two years are currently available), increased usage is anticipated.

The ad hoc query capabilities of the system, required by the original goals but only peripherally addressed by the committee, appear to be the more successful aspect of the system. Those who have committed the time to learning the query language and the structure of the data in the system find it very useful for tasks requiring the aggregation of information about faculty and staff members. However, it appears that the varying levels of expertise in the use of the query capabilities of this system reflect the varying levels of computer expertise

in the user community in general. The only known exception is one case in which development of skill in using the FIS was actively encouraged by a supervisor as a means of job enhancement for a new user.

It also appears that little effort was devoted to encouraging people to alter established work patterns. All users were offered training by Administrative Systems in the use of the system, and the majority attended these classes. Individual assistance is available through a phone call. However, the information contained in the system can still be obtained from paper copies, and staff members are accustomed using these sources. Clearly, the successful development and operation of a system designed to meet the needs of users does not automatically translate into alterations in work patterns and use of the system.

Finally, in order to meet specific, complicated information needs, users requested assistance in the form of standardized queries and reports. These would facilitate quick retrieval of information by users who are less knowledgeable about the database and the query language, and provide a common set of tools for all users. These requests have yet to be fulfilled, but their completion, scheduled for this summer and fall, should encourage increased usage.

An evaluation of the design effort itself is also necessary. This effort had both positive and negative aspects, and problems have been identified which should aid in future design efforts. The design process can be described as largely successful. Attendance at committee meetings was excellent. Committee members often arrived with comments, questions, or issues and provided considerable input. Members were cooperative and, after relatively brief discussions, were able to reach a consensus. Although use is not as heavy as we might have hoped, users are satisfied with the content and the appearance of all currently functional aspects of the system. Further, administrative and college users were successful in merging their varying perspectives to achieve a common goal. This may be one of the most important and enduring aspects of this design effort.

The primary disadvantage of this methodology was its costliness in terms of time. It required many meetings to design each screen, and delays were inevitable as AS system designers were required to conduct investigations about whether a requested combination of data elements would be possible with available information. Expectations were raised and lowered as deadlines were missed; completed screens were sometimes sent back to the drawing board for the incorporation of a new suggestion or requirement. In evaluating this aspect, two changes are recommended. First, more up-front analysis of user needs and of the the originating systems should be undertaken before convening the first committee meeting. Second, a means is needed to establish when a segment of the project (e.g. a screen) is complete according to specifications. This should be coupled with a standardized method for requesting changes or additions and an on-going schedule for implementation.

This is not an evaluation of a completed project, but rather of an on-going effort. Some of the lessons learned in this project have been incorporated into the new administrative database design effort. Other questions, particularly those relating to use of the system, will not be finally answered until the system has been in operation for a longer period of time.

FUTURE DIRECTIONS

In an ideal world, all university information would be stored in one location and any combination of data elements would be easily, even immediately accessible. This is consistent with Joplin's (1980) "guiding principles of data base construction": the database should contain information from all university components and be stored in one central location. CMU is moving in this direction by planning for the development of a University Information System (UIS). As a first step in this project, the FIS is being merged with Student Records data to form a single relational database system using INGRES on a mainframe computer. It is anticipated that the UIS will eventually encompass data on space, student accounts receivable and financial aid.

This project will provide authorized campus users with retrieval-based access to Student Records, Payroll/Personnel and other data without allowing access to the originating systems,

much as was done with the FIS. The UIS is not intended to replace or change any of the current production systems. However, these production systems are also scheduled for replacement over the next few years. The new production systems will be fully compatible with INGRES and will continue to support the integrated functions of the UIS.

The incorporation of the FIS into the UIS involves a re-design of the underlying database structure which will make the FIS fully compatible with the Student Records data. For example, basic biographical data common to both systems will be stored in a single biographical table. The new structure will make it easier for users to query the database since data on all employees will be fully and consistently integrated. The permanent link with the Student Records data will also facilitate the resolution of data problems encountered in the original FIS design process. The screens already in operation in the FIS will be reproduced in the new system with some variations resulting from the new underlying database structure. Requests for standard reports and queries will also be fulfilled in the new system. One of the specific project goals for this integrated system is its use for the production of university teaching load analyses.

The design-by-committee approach is also being used in this project and incorporates most of the changes suggested in our evaluation. Institutional Research personnel have devoted considerable time to the analysis of user needs, based on individual interviews, and are preparing a user specifications document. Administrative Systems personnel are undertaking a thorough analysis of data items in the originating systems. This groundwork is required to insure completion of the project in a much shorter time period than required for the FIS. The initial deployment of the UIS is planned for the Fall of 1986.

The ability to extract data from the University Information System and move files across a network to personal workstations will be stressed during the training phase of the UIS project. Initially, users will be encouraged to obtain desired data sets by using standard programs or ad hoc queries and to download these to their personal computer for further analysis. With the release of INGRES's distributed database technology the UIS can be

transformed into a truly distributed system, with data sets residing on servers and workstations connected to the campus network. This new technology will offer faster access to shared sets of data and will move away from a single mainframe source.

This is an ambitious project, but one which should serve to meet campus needs for university information in a manner which was not possible several years ago. It is expected that this new system will be of great benefit to the Institutional Research and Planning process and will provide unique opportunities for members of the campus community to obtain and use university operating data.

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